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PERFORMANCE OF WIND-POLLINATION FAMILIES AND INTRA- AND INTER-STAND CROSSES ON CONTRASTING FOREST SOILS

by

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ABSTRACT

Eighteen Douglas-fir families were raised for 3 years in two forest soils of different productivity. Family effects were highly significant, but there was no family x soil interaction. Wind-pollination seeds weighed less and wind-pollination seedlings were shorter than cross-pollination seeds and seedlings.

Keywords: Pollen dissemination, Douglas-fir, seedlings, soils, plant genetics.

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INTRODUCTION

Plant hybridization has been used in crop breeding to increase productivity. However, a number of reports have indicated that the additional vigor associated with hybridization may frequently be environment dependent, that is, it is expressed to a different degree in different environments (Bucio Alanis 1966, Bucio Alanis and Hill 1966, Burton 1968, Harvey 1939, Langner 1951, Lewis 1955, McWilliam and Griffing 1965, and Pederson 1968). Many tests investigating this dependence have looked specifically at the temperature factor (Langridge 1962), where it was found that hybrid superiority tended to increase at higher than optimum growing temperatures. However, other factors of the environment such as plant nutrition (Harvey 1939) and site in general (Langner 1951) have also been shown to influence the expression of hybrid vigor. In total, these observations indicated that a general relationship might exist between the expression of hybrid vigor and environmental conditions such that hybrid superiority is greater in nonoptimal than in optimal growing conditions. The present limited test was established to investigate this by evaluating tolerance of three types of crosses to two soils of greatly different productivity. The three types of crosses are representative of what might be made within a local tree improvement unit.

The three types of progenies were "inter-stand" (male and female parents growing in a similar topographic location but separated by 10-15 miles), "intra-stand" (male and female parents separated by 1/2 to 1 mile), and open-pollination. The two soils were forest top soils brought in to a common nursery environment. Differences in the tolerances of the different progeny groups were evaluated by examining the progeny x soil interaction term in the analysis of variance.

The three types of progenies were originally produced in each of three locations. Progenies from two locations were too greatly reduced during cone handling and by insects for further analysis. This report describes the performance of the remaining set.

MATERIALS AND METHODS

The progenies consisted of the 18 crosses among six seed trees and three pollen mixes. The six seed trees were in a second-growth stand at 800- to 1,000-foot elevation in the western foothills of the Cascade Range.[1] Pollen mixes were (1) a local mix from six trees growing 1/2 to 1 mile away from

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[1] The author expresses his gratitude to the U.S. Plywood-Champion Papers, Inc., for permission to work in this area.

and at the same elevation as the seed trees ("intra-stand" crosses), (2) a pollen mix from six trees growing about 10 miles away from the seed trees and at 300- to 500-foot difference in elevation ("inter-stand" crosses), and (3) wind-carried pollen during a year of heavy pollen production.

Pollen trees in group 1 were second growth. Pollen trees in group 2 were both second growth and remnant old growth in land partially cleared for pasture. Both areas were on the rolling foothills which decline in elevation westward from the mountains. Douglas-fir was the dominant tree throughout the area.

Two forest soils of greatly different natural fertility and productivity (Lavender 1962, tables 3, 4, and appendix; this paper, table 3) were used for the test environments. The soils, called Burnt Woods and Black Rock Poor, were from the Oregon Coast Ranges 40-50 miles east of the seed trees. Both soils supported natural stands of Douglas-fir.

In the spring of 1965, newly germinated seeds were pricked-in at 3-inch spacing in two 24-inch-deep coldframes filled with Burnt Woods or Black Rock Poor topsoils. Cultural treatments consisted of summer watering and weeding. Plant heights were measured at the end of each growing season for 3 years. Date of bud burst was recorded at the beginning of the second year. Analyses of third-year height growth and total height and date of bud burst are reported here.

The experiment included the effects of different soils, seed trees, and pollen sources. Within each soil there were three randomized blocks with 10 seedlings per family per block. Soil was treated as a fixed effect, progenies fixed, female parents random, and pollen sources fixed. Pollen sources were fixed in the sense that they sampled pollen coming from selected distances from the seed trees. Because variances were approximately proportional to seedling size and annual height growth, measurements were transformed to natural logarithms before analyzing. Figures in the tables are retransformed from the natural logs.

RESULTS

Plants in Burnt Woods soil were three to four times as large as plants in the Black Rock Poor soil after 3 years (table 1), so the soil environments did provide the contrast of good versus poor growing conditions.

Seed parent (female effect) and pollen source (male effect) were significant for all traits (table 2). None of the interactions was significant. The

Table 1.--*Third-year leader length, 3-year tree heights and second-year dates of bud burst for plants growing on the two contrasting soils*

Trait	Productive soil	Nonproductive soil
Third-year leader length (cm)	40.1	11.4
3-year seedling height (cm)	59.3	17.4
Date of bud burst (days from Jan. 1)	96.2	98.8

Table 2.--*F-values for analyses of variance of third-year leader length, 3-year total height, and date of second-year bud burst*

Source of variation	F-values and significance levels		
	Third-year leader growth	3-year total height	Date of bud burst
Progenies	[1]3.38	[1]3.95	[1]5.63
Females	[1]8.41	[1]9.86	[2]3.40
Males	[1]8.00	[2]6.56	[1]62.63
Wind vs. controlled cross	[1]15.24	[1]27.00	[1]40.77
Intra- vs. inter-stand	.82	.56	[1]84.49
Females x males	.59	.48	.58
Soils x progenies	.57	.60	1.29
Soils x females	.69	.61	1.05
Soils x males	.54	.46	1.56
Soils x females x males	.55	.66	1.27

[1] Calculated F exceeds 1-percent tabular value.

[2] Calculated F exceeds 5-percent tabular value.

families, irrespective of pollen treatment, gave the same relative performance in both of the soils.

If we look only at the growth traits, it can be seen that the pollen-source effect was due to the difference between open-pollination progenies and progenies from controlled crosses. Table 3 shows the development of height-growth differences for the three growing seasons. The differences were quite consistent; cross-pollination families averaged 14 percent greater stem elongation the first year, 8 percent the second year, and 10 percent the third year.

DISCUSSION

Any evidence for differences among progenies in tolerance to the two soils would appear in the soils x progenies interactions. In this test, interaction terms did not even approach statistical significance (table 2). These results contrast with several of the reports cited previously. However, in those tests the crosses were generally between species, varieties, or inbred lines. Such hybrids in Douglas-fir might also show greater tolerance to environmental variability. In this test, the most distant parents were separated by about 15 miles and 500 feet in elevation, a spread that is within the range of our local tree improvement units. Under these conditions, there is no evidence that distance between parents affected the environmental tolerance of the progeny.

Table 3.--*Average leader length of wind- and cross-pollinated progenies during each of 3 years in productive and nonproductive soils*

Year	Productive soil		Nonproductive soil	
	Wind progenies	Cross progenies	Wind progenies	Cross progenies
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First year (epicotyl length)	8.6	10.2	3.0	3.5
Second year	15.3	16.6	4.6	5.0
Third year	38.7	41.4	10.8	12.4

There was, however, a significant difference between progenies. Both male and female effects were highly significant. Of particular interest was the difference in vigor. The male effect was all due to the contrast between cross- and wind-pollination progenies. The yearly height increment of the wind-pollination progenies was consistently 8 to 12 percent less than that of the cross-pollination progenies (table 3). Height growth of inter- and intra-stand progenies did not differ.

The two most likely contributors to this growth difference were differences in coefficients of inbreeding and differences in seed weights. Previous data and calculations on the amount of selfing arising from wind pollination in natural stands have indicated an inbreeding coefficient of about 0.07 in wind-pollinated Douglas-fir progenies and an accompanying inbreeding depression in seedling height growth of about 1.5 to 2.0 percent (Sorensen 1973). The remainder of the growth reduction in height (about 6 to 10 percent, depending on year and soil) was presumably the result of seed weight differences. On the average, wind-pollination seeds were 20 percent lighter than cross-pollination seeds (1.11 and 1.39 grams per 100 filled seeds, respectively).

The exact cause of the seed weight difference is unknown. However, Rohmeder and Eisenhut (1959) have reported that many types of pollination bags create their own particular microenvironments, and it was assumed that some aspect of the bag environment caused the bagged seeds to be heavier. In our pollinations, we used the same isolation bags both to isolate from pollen and to protect from insects, so the cross-pollinated cones were exposed to the bag microenvironment for the entire season.

This effect has been observed in several additional tests and identifies a factor which must be kept in mind when making general comparisons between the growth of wind-pollination and cross-pollination seedlings. How long the effect will last is not known, but it lasted 3 years in this test and in absolute terms was greater at the end of the third year than at the end of the first.

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